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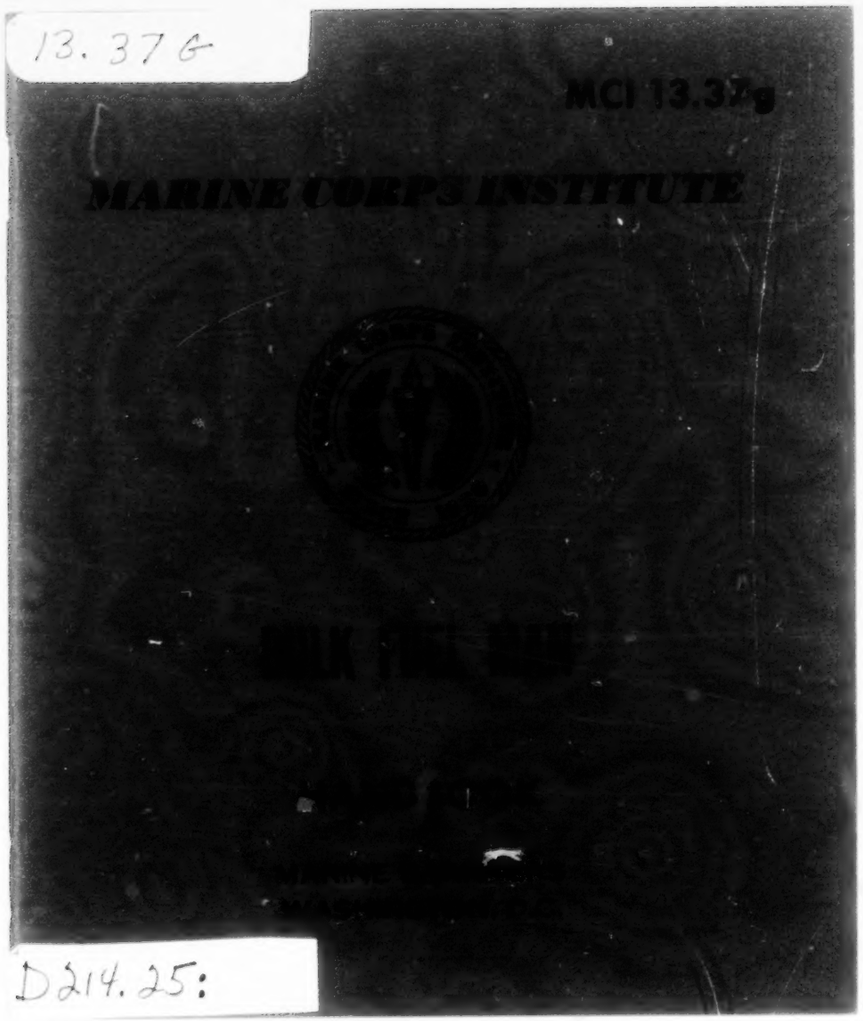

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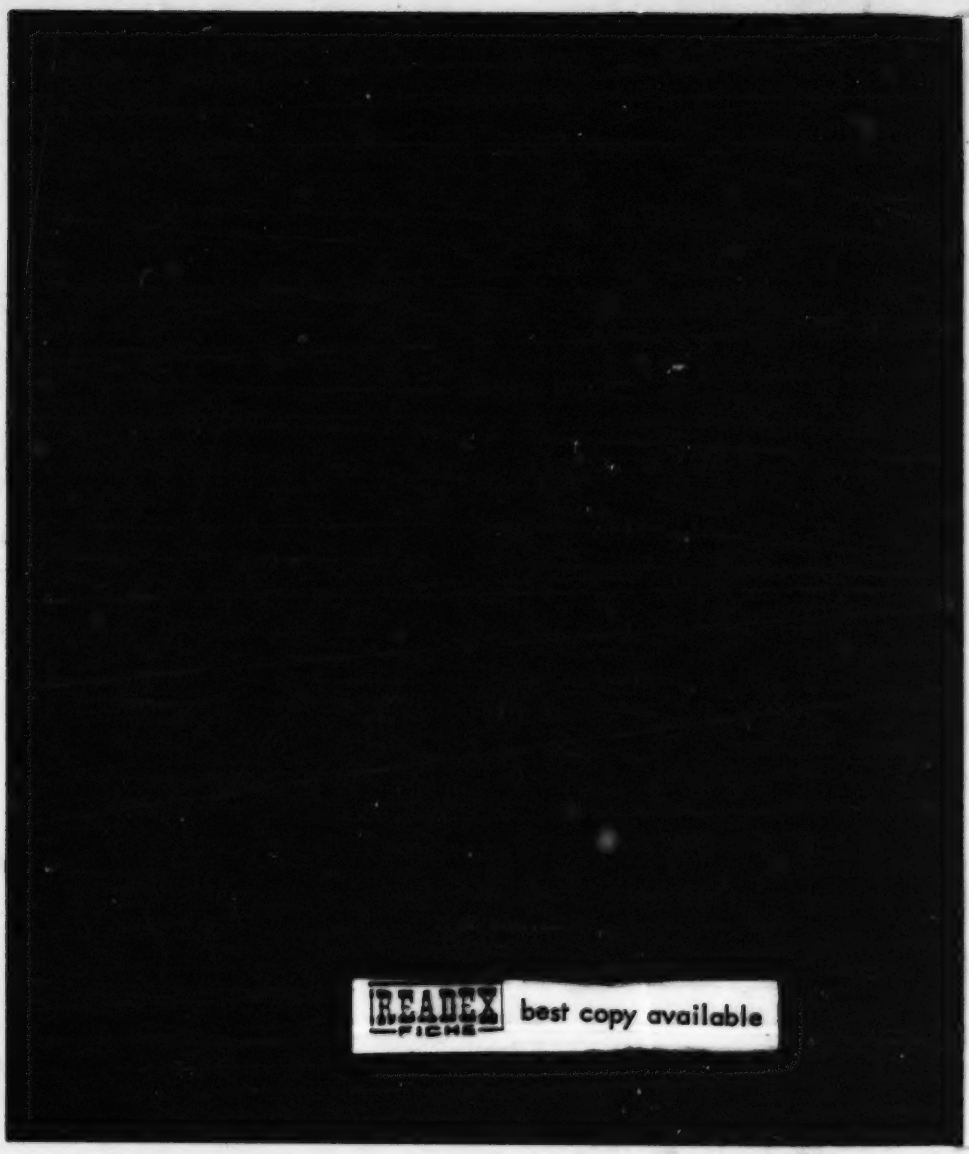
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ACKNOWLEDGMENT

The Marine Corps Institute, Marine Barracks, Washington, D. C. gratefully acknowledges the important contributions provided by the following MCI personnel in developing and publishing this course.

Course Developer . . . . . GySgt J. R. Younce

Officer in Charge . . . . . Capt D. G. Reist

Education Specialist . . . . . Betsy A. McCleary

Course Editor . . . . . Ms. Monica L. Noell

Wordprocessing Technician . . . . . LCpl M. Howe

Graphics Illustrator(s) . . . . . Cpl R. I. Frankhauser

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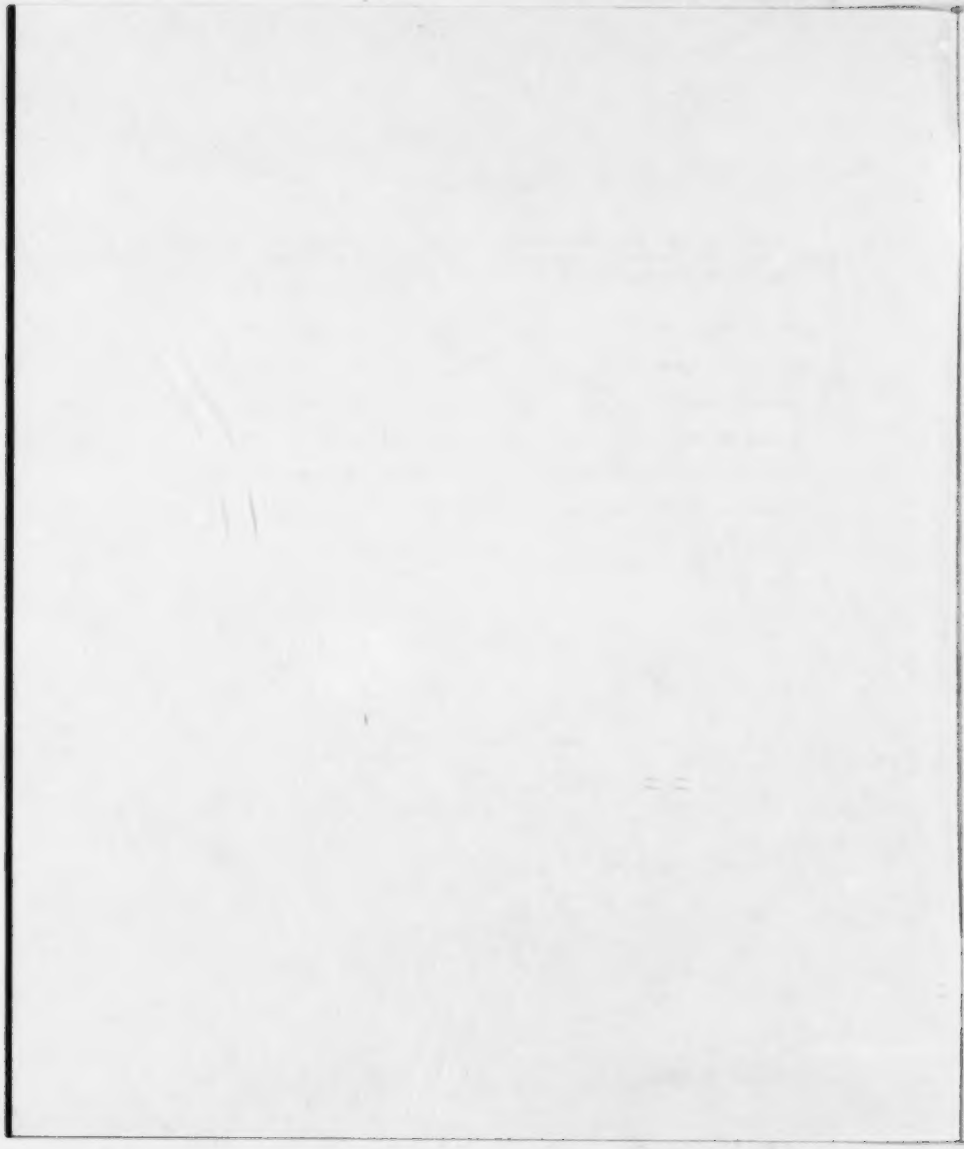


1. History. During World War II, the fuel demands of the Marine division in the assault placed a heavy burden on the fuel handling facilities of the shore party. With 5-gallon cans and 55 gallon drums, the minimum fuel requirements were barely met. The Commandant of the Marine Corps directed the Marine Corps equipment board to establish a project for delivering fuel during amphibious operations. The concept of this method was developed by the Marine Corps and proposed in 1952. The development of the amphibious assault fuel system has progressed gradually into its present form.

2. Mission of Amphibious Assault Fuel System (AAFS). The primary mission of the AAFS is to supply class III and III (A) fuel to elements of the air-ground task force, to include distribution to, but not within air bases, to assure that class III (A) products distributed to supported air bases are the required type, quality and purity.

3. Employment. The AAFS is employed to receive fuel over the beach for storage and use ashore. The major assemblies of the AAFS are one beach unloading assembly, two fuel dispensing assemblies and one drum unloading assembly. Fuel is stored temporarily and can be transferred to another storage site or dispensed to individual containers, vehicles, tank trucks, or aircraft. The basic capacity of the AAFS is 600,000 gallons, made of five 120,000 gallon tank farms. The total storage capacity would be 720,000 gallons, including two booster pump assemblies and one beach unloading assembly. The AAFS system can be tailored to increase or decrease capacity by adding or deleting tanks and accessories.

4. Installation

Each major component is constructed in such a way that it may be installed without the use of special tools.

A complete system can be ready for operation in 48 to 72 hours after the initial assault.

Each major component is capable of functioning continuously, with proper care and maintenance, for a period of 45 days or more without replacement.

5. Site Selection

The terrain is the most important factor when installation of an AAFS is set up.

When fuel transfer operations are carried out in very hilly terrain, the booster pump assemblies may be only 50 to 100 meters apart.

The terrain must accommodate amphibious craft.

6. Discription of Components

● Collapsible Tank. Each system has 36 collapsible tanks constructed of impregnated fabric with filler and discharge assemblies. Each collapsible tank has a capacity of 20,000 gallons, and has a ground cloth appropriate to the size and shape of the tank and fitted with hand straps. The ground cloth is installed under the tank for protection from sharp rocks or other protrusions. Each tank will have its own light weight metal tank chest, for transporting collapsible tank, fittings, ground cloth, and a emergency repair kit. The chest is equipped with carrying handles, lifting hooks, towing eyes, and forklift cutouts, for movement by hand or heavy equipment.

●Hoses. There are two type of hoses supplied for the AAFS. The suction hose is wire reinforced to prevent collapse under high vacuum and is not intended to withstand high positive pressure. The discharge hose will collapse under vacuum but will withstand operating pressure of up to 125 (PSI's) pounds per square inch. Each section of hose is equipped with a quick-disconnect adapter (male) at one end and a quick-disconnect coupler (female) at the other end. Such hose comes in 2-inch and 4-inch sections, and discharge hoses comes in 2-inch, 4-inch and 6-inch sections.

● Pump. The 600 GPM pump is the standard pump for the AAFS system. The trailer-mounted, self priming, centrifugal pump is a self-contained unit for pumping gasolines, jet fuels, and diesel fuels. The 600-GPM pump is diesel-driven, with suction and discharge sides each having two 4-inch and one 6-inch ports.

●Meter Assemblies. The AAFS has 3-inch and 2-inch skid mounted meter assemblies provided to measure the amount of fuel delivered. The 3-inch meter has fittings to permit installation into a 4-inch hose line. This meter registers flow rates from 50 to 650 GPM at a maximum pressure of 200 psi. It has a register that can be reset for each individual operation and a cumulative read out. The 2-inch meter registers flow rates from 25 to 250 GPM and the meter can be reset in order to register each delivery.

● Pressure Regulator. The pressure regulator is used to control excessive pressure in the fuel transfer lines. Its main use is in the down grade side of steep terrain between two pumping stations or between a pumping station and a tank farm.

●Filter Separator. This assembly is a self-contained, skid mounted unit, which is of a vertical type design and aluminum construction, designed to remove solids and undissolved water from light petroleum fuels.

●Fuel Monitor. The fuel monitor is installed down stream of the filter separator to monitor the solid contaminants and undissolved water in fuel being dispensed. If the contaminants or water exceed a safe level, the monitor will shut off all flow. During normal operations the fuel monitor has a maximum operation of 400 GPM with clean fuses.

● Strainer. The 6-inch strainer is designed to remove large particles of contamination, such as sand or rust, from fuels as they are pumped ashore. This design allows for cleaning one side of the strainer while fuel continues to flow at a reduced rate on the other side.

● Manifolds and Fittings

Drum Unloading Valve. The drum unloading valve is used with the drum unloading manifold to empty 55 gallon drums or 5 gallon cans into collapsible tanks. The drum unloading manifold has one 4-inch male adapter and three 2-inch female couplers.

Fuel Dispensing Manifold. The fuel dispensing manifold is designed to be connected to a 4 inch discharge hose to feed three 2-inch discharge hoses connected to fuel nozzles. The fuel dispensing manifold has one 4-inch female fitting and three 2-inch male fittings.

Skid Mounted Manifolds. There are two sizes of skid mounted manifolds, 4-inch and 6-inch in an AAFS. The manifolds are equipped with either five (two inlet, three discharge) or six (three inlet, three discharge) ports. The primary use of the manifolds is in fuel distribution to tanks and in recirculation of fuel.

Wye fittings. There are two types of wye fittings that are provided to make connectors for various functions in an AAFS. One type has one adapter and two couplers (ACC), and the other has one coupler and two adapters (CAA).

Sight Indicators. The AAFS includes 2-inch and 6-inch sight indicators which are inserted in the appropriate size hose lines to indicate fuel flow by vane movement.

Reducers. For ease in interconnecting 6-inch and 4-inch segments of the fuel system, reducers are furnished. One type (6C x 4A) has a 6 inch coupler with a 4-inch adapter. The other (4C x 6A) has a 4-inch coupler with a 6-inch adapter.

Flanged Adapters. The AAFS is provided with 4-inch quick disconnect adapters with 3-4-6-and 8-inch flanges for connection to off shore fuel sources.

● Fuel Servicing Gravity Nozzle. The fuel servicing nozzle is used to dispense fuel to vehicles and individual containers. A nozzle stand is furnished for use at dispensing points to keep nozzles from picking up contamination when not in use.

● Nestable Pipe Culvert. The nestable pipe culvert is made from 2 feet lengths of currugated galvanized steel half sections, 10 inches in diameter. A total of 120 liner feet of culvert is included in each AAFS system, to provide a protected path under roads or in other places where vehicular traffic could damage the hose.

●General Repair Kit. The general repair kit contains spare parts, gaskets, gages and a limited number of tools for the routine maintenance, replacement, and repair of individual components in the fuel system. The kit is contained in three chests that are similar to, but smaller than the tank chest. The general repair kit is in addition to the emergency tank repair kit furnished with each tank; the two should not be confused.

●Valves. The hand operated valves in the system are of the rising stem type, of standard design, and made from anodized aluminum alloy. Gate valves with couplers and adapters in 4-inch and 6-inch sizes are in the AAFS.

7. Fire Extinguishers

FireFighting Truck, MCI-105I. Its used to combat fires in fuel installations. It is a dry chemical firefighting vehicle that uses "purple K powder," a dry potassium chemical, which is delivered under pressure, by means of two 50 feet hoses, at a range of 35 feet beyond the nozzle. It also has two, hand-portable dry chemical fire extinguishers that are brackets located on the front bumper.

Twin Agent Skid Mounted. This fire extinguisher is designed and constructed to be particularly effective in fighting fires generated by hydrocarbon fuels. It is intended for use in providing fire protection to the AAFS. It uses both chemicals and aqueous film foaming foam. These twin agents are stored in containers on the extinguisher. A remote hose cart is provided with the unit.

Thirty Pound Hand Type. The 30 lb. extinguisher is used to fight small fires in localized areas, such as engine or gasoline spills. It has a range of 17 feet and will operate for 8 to 12 seconds.

8. Protective Clothing

Successful extinction of fires within berms requires a close in location for the fire extinguisher operators. This is necessary because of the limited range of the fire extinguishers and the limited quantities that they provide. This closeness to the fire makes it essential that Marines wear suitable protective clothing. This clothing is available in the following:

Hood, Firemans, Aluminized, Proximity
Coat, Firemans, Aluminized, Proximity
Trousers, Firemans, Aluminized, Proximity
Coveralls, Firemans, Aluminized, Proximity
Boots, Firemans, Cold Weather
Gloves, Firemans, Aluminized, Proximity

1. A Brief History of Tactical Airfield Fuel Dispensing System (TAFDS) and Helicopter Expedient Refueling System (HERS)

a. During World War II, fuel and petroleum related products comprised between 55 and 60 percent of all supplies shipped overseas. During the Korean War this percentage had increased to 73 percent. The fuel needs of the Marine Amphibious Forces were barely met with 5 gallon cans and 55 gallon drums. At the direction of the Commandant. The Marine Corps developed a concept in 1952 for fuel delivery in amphibious operations. This concept proved workable and evolved into the Amphibious Assault Fuel System (AAFS), the Tactical Airfield Fuel Dispensing System (TAFDS), and the Helicopter Expedient Refueling System (HERS).

b. During the Vietnam conflict, these systems were combat tested from the 17th parallel south to the Mekong Delta and were successful. The majority of fuel issued to Marine Corps units was issued through either AAFS or TAFDS. The AAFS fuel farm at Chu Lai consisted of 120 10,000 gallon fuel tanks or 1,200,000 gallons of gasoline, diesel fuel, aviation gasoline, and JP-5 jet fuel. This system operated from September 1965 until 1968 when the Navy installed rigid steel tanks and assumed responsibility for the operations.

c. Since 1973, when the Marine Corps left the Republic of Vietnam, the Marine Corps has improved and increased the capacity of the AAFS and the TAFDS.

2. The mission of TAFDS and HERS

a. The TAFDS and HERS mission is to receive, store, transfer, and dispense liquid aviation fuels in an approved quality to Marine aviation units. The TAFDS and HERS are not limited to aviation fuel and may provide tactical fuel support also.

b. The majority of aviation fuel will be provided to TAFDS and HERS from the Amphibious Assault Fuel System (AAFS).

c. The TAFDS is a fairly simple, versatile, air transportable aviation fuel dispensing system capable of receiving and storing up to 120,000 gallons of fuel and simultaneously dispensing fuel from 18 refueling stations in an ideal situation. The TAFDS can receive fuel from the AAFS or has the drum unloading capability.

d. The following is a list of the major components of a TAFDS and their basic function in the system.

1. Three 600/350-gpm pumps used to transfer fuel from the fuel tanks to the dispensing points.

2. Six 20,000 gallon rubber impregnated nylon tanks with chests used to store aviation fuels.

3. Six 350-gpm filter separators are used to insure that clean quality fuel is issued.

4. Six fuel monitors (go-no-go) assist the filter separator in maintaining the quality of the fuel issued.

5. One 4-inch manifold (spider) assembly, a skid mounted unit with either five or six gate valve controlled ports, used for fuel distribution and recirculation.

6. Three 3-inch meter register assemblies used to measure the amount of fuel issued or recirculated.

7. Twelve 2-inch meter register assemblies used to measure the amount of fuel issued at individual issue points.

8. Eight 2-inch x 25 foot suction hoses, used to remove fuel from 55 gallon drums.

9. Nineteen 4-inch x 25 foot suction hoses used to connect the tank to the pumps.

10. Thirty-six 2-inch x 25 foot discharge hoses used at the issue points.

11. Sixty 4-inch x 50 foot discharge hoses used at the main fuel line.

12. Thirty 4-inch hand operated gate valves to control flow of fuel within the sytem.

13. Twelve coupler coupler adapters (CCA) wyes and eight adapter adapter couplers (AAC) wyes used to make connections adapting two lines from one or one line into two.

14. Six fuel dispensing mainfolds used to divide the four inch main line into three 2-inch dispensing lines.

15. Eight drum unloading manifolds used to empty 55 gallon drums.

16. Eighteen pressure locking nozzles used to refuel aircraft.

17. Twelve (gravity flow) fuel servicing nozzles used to refuel drop tanks from aircraft.

18. One general repair kit, which consists of three chests of repair parts, clamps, couplings, gaskets, nozzles, pre-formed packing, and kits. These kits are the evacuation kit, used for purging fuel from the hoses, and the explosiometer gas indicator set, used to detect gas and explosive vapors. The general repair kit also contains plugs and clamps used in the repair of the collapsible tank.

19. Each system will have a nestable culvert to protect hoses, nozzle stands to elevate the nozzle from the ground, and individual tank repair kits. The system will have a number of other miscellaneous items that you will work with.

1. The purpose of the Helicopter Expedient Refueling System (HERS).

a. The HERS is an air transportable, modular, refueling system, capable of being set up without any special hand tools.

b. The HERS was initially designed to refuel helicopters at remote sites and locations. With the introduction of the AV-8 Harrier, the HERS has assumed the responsibility of providing fuel at any location from which this aircraft can operate.

c. The HERS will provide all the equipment necessary to refuel helicopters and V/STOL aircraft at remote locations and sites, at a rate of 50/100 gallons of fuel per minute.

2. Major components of the HERS and their basic functions.

1. Two 50-gpm or 100-gpm pumps which will be used to transfer fuel from the fuel drums to either helicopters or V/STOL aircraft.

2. Eighteen 500 gallon rubber impregnated fabric collapsible fuel drums, which can be used to transport and store aviation fuel.

3. Two 50-or 100-gpm filter separator fuel monitor assemblies which will be used to ensure only that specification fuel is issued to the aircraft.

4. Four 2-inch meter assemblies which will be used to measure the amount of fuel issued.

5. Twenty-four 2-inch x 10 foot suction hoses, used to connect the fuel drums to the pump.

6. Six 2-inch x 50 foot discharge hoses, used between the pump and the issue point.

7. Four fuel and oil nozzles (Standard gravity flow) and four pressure nozzles to enable the HERS to fill aviation and the capability to be used at a vehicle fueling system.

8. Four nozzle stands to elevate the nozzle from the ground to keep contamination away from the nozzle and the fuel.

9. Miscellaneous items such as couplers and adapters to enable quick connections between hoses.

1. Maintenance Categories

a. Organizational. Organizational maintenance is that which is the responsibility of and is performed by the using organization. It normally consists of inspecting, servicing, lubricating, adjusting and replacing parts, and minor assembly not requiring highly technical skills. It includes first echelon maintenance performed by the operator, and second echelon maintenance performed by specially trained personnel in the using organization.

b. Intermediate. Intermediate or field maintenance is maintenance authorized and performed by a designated maintenance activity in direct support of the using activity; third echelon by higher echelon maintenance units; fourth echelon supporting the direct support maintenance activity; and is normally limited to replacing parts and assemblies. Intermediate maintenance units also support using organizations with special assistance mobile field repair teams; and repair parts.

c. Depot. Depot maintenance is repair involving major overhaul or complete rebuilding of parts and assemblies of the end items. Depot maintenance is fifth echelon.

2. Maintenance Echelons

a. Organizational Maintenance

(1) First Echelon Maintenance. Is performed by the user, wearer, operator, or crew.

(2) Second Echelon Maintenance. Is performed by specially trained personnel in the using owning organization.

b. Intermediate Maintenance (Field Maintenance)

(1) Third Echelon Maintenance. Is performed in direct support (DS) of, and, in some cases, by using units and is limited by authorized tools, test equipment, and spare parts.

(2) Fourth Echelon Maintenance. Is usually performed in rear areas by units in general support. Normally, next higher organizational echelon than direct support unit, and is limited by authorized tools, test equipment, and spare parts. Also covers calibration.

c. Depot Maintenance. Fifth Echelon Maintenance is major overhaul or complete rebuild. The purpose of learning 1st, 2nd, and 3rd echelon maintenance is to know how to repair the pump, when you are in a field environment, where you would have to know the higher echelons of maintenance.

First Echelon Maintenance

1. First Echelon Maintenance is the action taken to keep material in a serviceable condition, and is the responsibility of every user, operator, or crew.

2. Performing First Echelon Maintenance

a. 600-GPM Pump

(1) Inspect the frame for cracks, broken welds, etc.

(2) Lubricate all grease fittings, oil all movable parts, and clean and grease battery terminals.

(3) Check for leaks from the gate valves and seals.

(4) Check the fluid levels--oils, battery electrolite, fuel, and radiator coolant. If any of these are low, fill to the full level.

(5) Inspect and tighten, as necessary, the battery connections and instrument panel connections.

(6) Inspect oil filters, air filters, and fuel filters; clean or replace if necessary.

(7) Tighten all loose nuts and bolts.

(8) Lights must be clean and working properly, especially if they are to be connected to a vehicle. Reflectors must be cleaned.

(9) Spot paint and clean the frame structure as necessary.

b. 350-GPM Pump

(1) Inspect the frame for cracks, broken welds, if any.

(2) Lubricate all grease fittings, oil all movable parts, and grease pintle hook.

(3) Check for leaks from the gate valves and seals.

(4) Check the oil level and fuel level; fill if required.

(5) Inspect oil filters, air filters, fuel filters. Clean or replace as necessary.

(6) Check spark plugs and ensure that the porcelain is not cracked and the wires are serviceable.

(7) Tighten all loose nuts and bolts.

(8) Spot paint and clean as necessary.

(9) The most important check you might make is to ensure that you have the starting crank.

c. Discharge Hose

(1) Check hoses for serviceable O-rings.

(2) The banding must be tight around the adapter and coupler ends. If it is loose the hose must be replaced or new banding installed.

(3) Check for cracks along the entire hose. If any cracks are encountered, the hose must be replaced.

(4) Camlocks must not be bent or broken.

(5) After fuel is in the hose, and if any seepage occurs, the hose must be replaced, or a fuel spill or fire could be the result.

(6) Prior to using a hose, ensure that it is free of all dirt and objects that could block the flow of fuel.

d. Suction Hose

(1) All procedures from paragraph c., above, regarding discharge hose apply to suction hose. Additionally, suction hose has steel wire mesh reinforcement. Therefore, when the hose is deformed, it must be replaced.

e. Filter Separator

(1) The frame must be thoroughly inspected for cracks and previous welds as the frame is aluminum and occassionally fails when handled.

(2) The filters must be checked before use. Determine when they were last changed and change if necessary. The installation data should be stenciled on the outside of the separator.

(3) The copper tubing must be inspected for cracks, holes, or kinks. If any discrepancies are discovered, they must be corrected before use.

(4) The sight glass should be clean and free of any loose material.

(5) All valves should turn freely and all nuts must be tightened.

(6) The drain valve must be tightened to prevent the loss of the fuel in the filter separator.

(7) All plugs and caps must be in place.

f. Fuel Monitor (Go-No-Go)

(1) The filter elements must be checked for previous use. The installation data should be stenciled on the outside of the monitor.

(2) The copper tubing must be inspected for cracks and leaks.

(3) The inlet and outlet gages must be checked for serviceability.

(4) The fuel monitor must be drained and cleaned prior to use.

(5) The frame must be inspected for cracks and broken welds.

g. Spider Manifold

(1) The gate valves must turn freely.

(2) The O-rings and gaskets must be inspected for serviceability.

(3) Plugs and caps must be in place.

(4) Spot paint and clean if needed.

h. Meters

(1) Inspect for cracks on frame. Replace if necessary.

(2) Meters must have caps and plugs.

(3) The adapter and coupler ends must be tight.

(4) The O-rings must be checked for serviceability.

i. Fire Extinguishers

(1) Twin Agent Unit (TAU)

(a) The frame structure must be inspected for cracks.

(b) The hose reel must be serviceable, with no cracks. The hose reel must turn freely.

(c) The pressure gages must have the required amount of pressure.

(d) The hoses must be serviceable, otherwise you will lose the pressure that is needed in an emergency situation.

(e) The PKP and light water must be at the full level.

(2) 150 pound fire extinguisher

(a) Hoses must be free of PKP that may be clogged due to moisture.

(b) The wheels must be oiled to ensure that they move freely.

(c) Gages must work; check for proper pressure.

(d) When checking the PKP, make sure you listen for air escaping from the small opening on top of the cap.

(3) 30 pound fire extinguisher

(a) Ensure that the level of PKP is correct.

(b) The cylinder must be sealed, with no holes.

(c) The hose must not have any cracks or holes.

(d) The nozzle should open and shut easily.

●FUEL CONTAMINATION AND QUALITY CONTROL●

Fuel contamination occurs when two or more grades or types of fuel are mixed by accident, or the fuel contains foreign matter such as dust, dirt, rust, water, gum, or emulsions. Contaminated fuel can cause engines of all types to malfunction. This reduces operational readiness and can result in injuries or death, as in the case of aircraft engine failure.

Quality control is the term used to describe the measures taken, tests made, and devices used to make sure the fuel is of a usable quality.

The quickest test to be made for quality control is the Appearance Test. The fuel should be clean, bright, and free of visible particles. The visual check allows for checks on the color to ascertain the types of fuel as shown in the table below.

Grade (use)	NATO symbol	Color
80/87 (MOGAS)	F-12	Red
100/130 (AVGAS)	F-18	Green
115/145 (AVGAS)	F-22	Purple
JP-4 (Jet B)	F-40	Clear to straw
JP-5 (Jet A, A-1)	F-44	Clear to straw

●Cloudiness indicates that water is present; the visible foreign matter is sediment. The contaminants and their effects are shown in the next table.

●To make this test, use a clean container such as a glass beaker, drum thief, or an object that you are sure is free from contamination. Take a sample from the nozzle or from a part of the tank that is distant from the inlet to the tank. Swirl the sample in the container to form a whirlpool. Sediment in the sample will accumulate directly under the whirlpool. Sediment limits are shown at the end of the next table. Particles or sediment in the sample indicate improper filter separator operation or possibly a source of contamination within the system. Check the system and replace the defective part.

●Clouds in the sample are finely divided water or emulsion. Usually, this means the filter-separator is operating improperly. Check the system and replace the faulty part. Acceptable limits of water allowed are shown following the next table.

Type contaminants	Appearance	Characteristics	Effects
Water:			
Dissolved water	Not visible.	Fresh water only. Precipitates out as cloud when fuel is cooled.	None, unless separated by cooling of fuel; then acts as free water.
Free water	Light or heavy cloud; droplets cling to sides of bottle, or large amounts on bottom.	Salt water or fresh water.	Icing of fuel system; erratic fuel gage readings; large amounts can cause flameouts; salt water corrodes components.
Sediment:			
Rust	Red or black powder, rouge, or grains; may appear as dye-like material in fuel.	Red rust (Fe_2O_3) nonmagnetic; black rust (Fe_3O_4) magnetic; rust generally comprises 70-90 percent of total sediment.	Causes sticking, sluggish or general malfunction of fuel controls, flow dividers, pumps, nozzles, etc.
Sand or dust	Crystalline, granular or glass-like.	Usually 0-30 percent of total sediment.	Same as rust.
Sediment: - Continued			
Aluminum, cadmium, or magnesium.	White or gray powder or paste.	Sometimes sticky or gelatinous when wet; usually 0-10 percent of total sediment.	Same as rust, and may lower flight range and high attitude performance.
Emulsions:			
Water in fuel	Light or heavy cloud.	Finely divided drops of water in fuel; same as free water cloud; will settle to bottom in minutes, hours, or weeks, depending upon nature of emulsion.	Same as free water.
Fuel in water	Reddish, grayish, or blackish; sticky material described as gelatinous, gummy, or "mayonnaiselike"; may appear as "globules" or stringy, fibrous material in clear or cloudy fuel.	Finely divided drops of fuel in water; contain rust which stabilizes or "firms" the emulsion; sticks to most materials normally in contact with fuels; may stand from days to months without separating; contains 50-70 percent water and 30-50 percent fuel.	Same as free water and sediment, but worse; causes filter plugging and erratic readings in fuel quantity probes.
Miscellaneous:			
Interface matter	Lacy bubbles or scum at interface between fuel and water; resembles jellyfish.	Caused by bacteria acting on chemicals in fresh water; may have "cotton egg" smell.	Same as free water; may leave deposits in fuel tanks.
Air bubbles	Cloud in fuel.	Disperse upward within a few seconds.	None.

Contamination Table

Type contaminants	Appearance	Characteristics	Effects on aircraft or engines
Water: Dissolved water	Not visible.	Fresh water only. Precipitates out as cloud when fuel is cooled.	None, unless separated by cooling of fuel; then acts as free water.
Free water	Light or heavy cloud; droplets cling to sides of bottle, or large amounts on bottom.	Salt water or fresh water.	Icing of fuel system; erratic fuel gage readings; large amounts can cause flameouts; salt water corrodes components.
Sediment: Rust	Red or black powder, rouge, or grains; may appear as dye-like material in fuel.	Red rust (Fe_2O_3) nonmagnetic; black rust (Fe_3O_4) magnetic; rust generally comprises 70-90 percent of total sediment.	Causes sticking, sluggish or general malfunction of fuel controls, flow dividers, pumps, nozzles, etc.
Sand or dust	Crystalline, granular or glass-like.	Usually 0-20 percent of total sediment.	Same as rust.
Aluminum, cadmium magnesium	White or gray powder or paste.	Sometimes sticky or gelatinous when wet; usually 0-10 percent of total sediment.	Same as rust, and may lower flight range and high attitude performance.
Emulsions: Water in fuel	Light or heavy cloud.	Finely divided drops of water in fuel; same as free water cloud; will settle to bottom in minutes, hours, or weeks, depending upon nature of emulsion.	Same as free water.
Fuel in water	Reddish, grayish, or blackish; sticky material described as gelatinous, gummy, or "mayonnaise like"; may appear as "globules" or stringy, fibrous material in clear or cloudy fuel.	Finely divided drops of fuel in water; contain rust which stabilizes or "firms" the emulsion; sticks to most materials normally in contact with fuels; may stand from days to months without separating; contains 50-70 percent water and 30-50 percent fuel.	Same as free water and sediment, but worse; causes filter plugging and erratic readings in fuel quantity probes.
Miscellaneous: Interface matter	Lacy bubbles or scum at interface between fuel and water; resembles	Caused by bacteria acting on chemicals in fresh water; may have "rotten egg" smell.	Same as free water; may leave deposits in in fuel tanks.
Air bubbles	Cloud in fuel.	Disperses upward within a few seconds.	None.

Sediment Contamination Limits

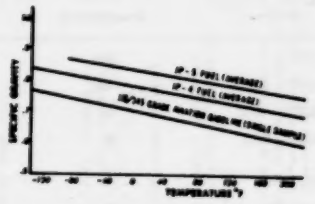
Sediment (mg/liter)	Fuel quality	Fuel system reliability	Acceptability
0.0 - 1.0	Clean	Excellent	Yes
1.0 - 2.0	Slight contamination	Good	Yes
2.0 - 5.0	Moderate contamination	Fair	Marginal
5.0 - 10.0	Heavy contamination	Poor	No
10.0 - plus	Gross contamination	None	No

Water Contamination Limits

Form of water	Amount of water (ml/liter)	Acceptability
None	0.00	Yes
Detectable visually	0.00 - 0.005	Yes
Trace	0.005 - 0.02	No
Light to heavy cloud	0.02 - 0.03	No
Heavy cloud	0.03 plus	No
Settled water	0.05 plus	No

Any evidence of microbiological growth requires stopping fueling operations and notifying the fuel control officer.

The specific gravity of a fluid is the weight of a given volume of the fluid compared to the weight of an equal volume of water at the same temperature. Water is assigned a specific gravity of 1.00, so a liquid lighter than water will have a specific gravity less than 1.00, and a liquid heavier than water will have a specific gravity of more than 1.00. As liquids are heated, they expand so that the same weight of liquid takes up more volume, and the specific gravity goes down. This change of specific gravity with temperature for various fuels is shown below. Since meaningful differences in fuels exist, specific gravities may extend out to four decimal places.



Variation of Specific Gravity With Temperature

Hence the API (American Petroleum Institute) developed a scale called degrees API gravity, which is easier to use with fuels. The relationship is expressed as follows:

$$\text{Degrees API} = \frac{141.3}{\text{Specific Gravity}} - 131.5$$

or

$$\text{Specific Gravity} = \frac{141.5}{131.5 + \text{degrees API}}$$

It can be seen that a fuel of 10^{0} API gravity has a specific gravity of 1.00, or is the same as water.

To make the gravity test:

Collect a fuel sample from a nozzle spout into a clean tall container so that there is enough fluid to float the hydrometer (about 150 milliliters or 1/3 pint).

Place a hydrometer with the proper scale for the fuel being tested into the hydrometer cylinder, and pour in the fuel sample until the hydrometer floats clear of the cylinder bottom. Record the degree API reading on the hydrometer scale. Record the temperature of the fuel.

The degree API reading should be compared with the reading recorded when the particular batch of fuel was last transferred. If this cannot be done, compare the sample reading with the degree API readings of samples that have been collected at regular intervals from the same fuel batch. This will insure detection of any change in specific gravity during storage or during dispensing operations.

Fuel received from tanks which handle several fuel types should be very carefully checked with a hydrometer. Fuel received from depot or refinery-sealed containers, such as drums or tank cars, is less likely to have been mixed with other fuel types, but should be hydrometer-checked as a matter of course.

The degrees API generally should not differ by more than 0.5°. If the 0.5° API is exceeded, check the sample with another hydrometer. If the limit is still exceeded, the fuel should not be used until adequate technical advice and/or laboratory analysis has been obtained.

Testing Intervals. The appearance and gravity tests should be performed at the following intervals:

a. Daily, prior to starting fuel dispensing.

b. Before dispensing fuel from or through a new dispensing system component.

c. When a new fuel grade is being handled.

d. When any doubt of fuel quality exists.

e. After recirculation of fuel.

Specific and API Gravity Ranges for Fuels
(Corrected to 60° F)

Grade	Specific gravity range*	API gravity range	Pounds per U.S. gallons**
80/87	0.72 - 0.695	65 - 72	5.961
100/130	0.727 - 0.689	63 - 74	5.928
115/145	0.716 - 0.685	66 - 75	5.857
JP-4	0.8017 - 0.7507	45 - 57	6.610
JP-5	0.8448 - 0.7883	36 - 48	6.830

*Estimated range.

**Based on average API gravity and to be used for estimating only.

API Gravity groups

Group No	Coefficient of Expansion	Corresponding degrees API	Range of group (Degrees API/60°)	Products normally in group
0	.00035	6	Up to 14.9	Heavy crude oils
1	.0004	22	15.0 to 34.9	Light crude oils Residual fuel oils (NSFO, FS Grades 4, 5, 6). Lubricating oils
2	.0005	44	35.0 to 50.9	Kerosene Heavy diesel fuels Solvents Jet fuels
3	.0006	58	51.0 to 63.9	Motor gasolines Light diesel fuels
4	.0007	72	64.0 to 78.9	Aviation gasolines
5	.0008	86	79.0 to 88.9	
6	.00085	91	89.0 to 93.9	Liquefied gases
7	.0009	97	94.0 to 99.9	

AIDS TO QUALITY CONTROL

Settling Time. After fresh stocks have been added, the maximum possible settling time should be allowed to allow water and solids to settle out. The following minimum times are recommended:

Three hours per foot of fuel depth for JP-5-type fuels.

One hour per foot of fuel depth for JP-4-type fuels and aviation gasolines.

Recirculation.

Recirculation is the process of transferring fuel from one part of a dispensing system, through every other part, into a empty or partially filled tank. Recirculation is used to remove as much water as possible from fuel. It also helps control existing gum and microbiological growth. Contamination possibility increases with idle time, but with tactical systems, periods of nonuse will seldom exceed 48 hours. So generally, pumping an amount of fuel equal to twice the amount in the installed hose will remove contaminants to an acceptable level. If a meter is installed, pump until twice the number of gallons in the hoses has been recirculated. With no meter installed, the time procedure below can be used.

A time for recirculation pumping can be determined as follows:

(1) Count and record the number of sections of installed hose of each size and length.

(2) Use the table below to find the total hose content in gallons. For example, if there are 15 sections of 6" x 50' hose, 21 sections of 4" x 50' hose, 12 sections of 2" x 50' hose, and 6 sections of 2" x 25' hose installed, the calculations, using the table below are:

Fuel Content of Hose*

Sections	6" x 50'	4" x 50'	2" x 50'	2" x 25'
1	73	33	9	4.5
2	146	66	18	9
3	219	99	27	13.5
4	292	132	36	18
5	365	165	45	22.5
6	438	198	54	27.5
7	511	231	63	31.5
8	584	264	72	36.0
9	657	297	81	40.5
10	730	330	90	45

*To nearest whole gallon

(3) The amount of fuel to be recirculated is twice the hose content, or 2 x 1,923 = 3,846 gallons.

(4) Divide the gallons to be pumped by the pumping rate in gallons per minute to find the pumping time in minutes. For the example above, if the pump is set for a delivery rate of 150 gallons per minute:

3,846 gallons - 150 gallons per minute = 25.6 minutes.

Rounding to the nearest minute, operate the pump for 26 minutes.

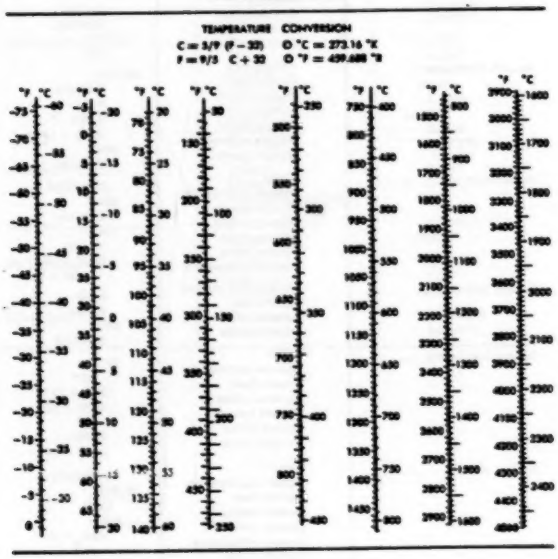
Acceptable recirculation procedures include any method of equipment connection that allows pumping fuel in a closed loop through every installed component (except gravity nozzles). The process and requirement applies to the TAFDS, AAFS, and refueler vehicles.

Recirculation is done at the times and on occasions specified in local regulations, but should always be done before beginning daily operation and before dispensing fuel when the equipment has not been used for defined periods in excess of 48 hours.

After recirculation, reconnect the system for dispensing, and take a fuel sample from a nozzle to make sure it passes the quality tests.

CONVERSION CHARTS

TEMPERATURE



AREA

To convert	To	Multiply by
Acres	Square feet	43,560
	Square yards	4,840
	Square miles	0.0015625
	Square meters	4,046.873
	Hectares	0.4046873
Hectares	Square yards	11,959.85
	Acres	2.47104
	Square miles	0.003861
	Square meters	10,000
	Square kilometers	0.01
Square centimeters	Square feet	107,600
	Square feet	0.001076
	Square inches	0.1550
	Square meters	0.0001
	Square miles	3.861×10^{-11}
	Square millimeters	100
	Square yards	0.000196
Square feet	Acres	0.0000296
	Square centimeters	929.0
	Square meters	0.09290
	Square inches	144.0
	Square yards	0.11111
	Square miles	3.587×10^{-8}
	Square millimeters	9.29×10^{4}
Square inches	Square centimeters	6.452
	Square feet	0.0944
	Square millimeters	645.2
	Square yards	0.000716
Square kilometers	Acres	247.1
	Square centimeters	10^{10}
	Square feet	10.76×10^{6}
	Square inches	1.550×10^{9}
	Square meters	10^{6}
	Square miles	0.3861
	Square yards	1.196×10^{6}
Square meters	Acres	0.0002471
	Square centimeters	10,000
	Square feet	10.76
	Square inches	1,550
	Square miles	3.861×10^{-7}
	Square millimeters	10^{6}
	Square yards	1.196
Square miles	Acres	640.00
	Square feet	27.88×10^{6}
	Square kilometers	2.590
	Square meters	2.590×10^{6}
	Square yards	3.098×10^{6}
Square yards	Acres	0.0002066
	Square centimeters	8,361
	Square feet	9.0
	Square inches	1,296
	Square meters	0.8361
	Square miles	3.228×10^{-7}
	Square millimeters	8.361×10^{5}

FLOW

To convert	To	Multiply by
Barrels/day	G. p. h.	1.75
	G. p. m.	0.0292
Barrels/hour	Cu ft/min	0.0936
	G. p. m.	0.7
Gallons/hour	Cu ft/hr	0.1337
	Cu ft/min	0.002228
	G. p. m.	0.016667
Gallons per minute	Bbl/day	34.2857
	Bbl/hr	1.4286
	Bbl/min	0.02381
	Cu ft/day	192.50
	Cu ft/min	0.1337
	Gal/day	1,440.0
	Liters/sec	0.6308
	Cu ft/sec	0.002228
Cu ft/min	Gal/sec	0.1247
	Liters/sec	0.4720
	Cubic centimeters/sec	472.0
Cu ft/sec	Million gals/day	0.646317
	Gals/min	448.831
Cu yards/min	Cu ft/sec	0.45
	Gals/sec	3.367
	Liters/sec	12.74
Liters/min	Cu ft/sec	0.0006586
	Gals/sec	0.004403

LENGTH

To convert	To	Multiply by
Centimeters	Feet	0.032281
	Inches	0.3937
	Kilometers	1×10^{-5}
	Meters	0.01
	Miles	6.214×10^{-6}
	Millimeters	10.0
	Mils	393.7
	Yards	0.01094
	Microns	10,000
Feet	Centimeters	30.48
	Kilometers	0.0003048
	Meters	0.3048
	Miles (Nautical)	0.0001645
	Miles (Statute)	0.0001894
	Millimeters	304.8
	Mils	12,000
	Microns	30,480.0
Kilometers	Centimeters	1×10^{5}
	Feet	3,281
	Inches	39,370.0
	Meters	1,000.0
	Miles	0.6214
	Millimeters	10^{6}
	Yards	1,094
Leagues	Miles	3
Meters	Centimeters	100
	Feet	3.281
	Inches	39.37
	Kilometers	0.001
	Miles (Nautical)	0.0005396
	Miles (Statute)	0.0006214
	Millimeters	1,000.0
	Yards	1.094
	Microns	1×10^{6}
Miles (Nautical)	Feet	6,080.27
	Kilometers	1.853
	Meters	1,853.0
	Miles (Statute)	1.1516
	Yards	2,027
Miles (Statute)	Centimeters	1.609×10^{5}
	Feet	5,280
	Inches	63,360.0
	Kilometers	1.609
	Meters	1,609.0
	Miles (Nautical)	0.8684
	Yards	1,760
Millimeters	Centimeters	0.1
	Feet	0.003281
	Inches	0.03937
	Kilometers	10^{-6}
	Meters	0.001
Millimeters	Miles	6.214×10^{-7}
	Mils	39.37
	Yards	0.001094
	Microns	1,000
Microns	Centimeters	1×10^{-4}
	Inches	3.937×10^{-5}
	Meters	1×10^{-6}
Yards (US)	Centimeters	91.4402
	Fathoms	0.05
	Feet	3
	Inches	36

LENGTH (Continued)

To convert	To	Multiply by
	Meters	0.9144
	Miles	5.68182×10^{-4}

VOLUME

To convert	To	Multiply by
Barrels (US)	US gallons	42
	Cubic inches	9,702
	Cubic feet	5.6146
	Imperial gallons	34.9726
	Liters	158.984
	Cubic meters	0.15899
Cubic centimeters	Cubic feet	3.531×10^{-5}
	Cubic inches	0.06102
	Cubic meters	10^{-6}
	Cubic yards	1.308×10^{-6}
	Gallons (US liquid)	0.0002642
	Liters	0.001
	Pints (US liquid)	0.002113
	Quarts (US liquid)	0.001057
Cubic feet	Cubic centimeters	28,320.00
	Cubic inches	1,728.00
	Cubic meters	0.02832
	Cubic yards	0.03704
Cubic feet	Gallons (US liquid)	7.48052
	Liters	28.32
	Pints (US liquid)	59.84
	Quarts (US liquid)	29.92
Cubic inches	Cubic centimeters	16.39
	Cubic feet	5.787×10^{-4}
	Cubic meters	1.639×10^{-5}
	Cubic yards	2.143×10^{-5}
	Cubic gallons	0.004329
	Liters	0.01639
	Mil feet	1.061×10^{6}
	Pints (US liquid)	0.03463
	Quarts (US liquid)	0.01732
Cubic meters	Bushels (dry)	28.38
	Cubic centimeters	1×10^{6}
	Cubic feet	35.31
	Cubic inches	61,023
Cubic meters	Cubic yards	1.308
	Gallons (US liquid)	264.2
	Liters	1,000

VOLUME (Continued)

To convert	To	Multiply by
	Pints (US liquid)	2,113.0
	Quarts (US liquid)	1,057.0
Cubic yards	Cubic centimeters	7.646 x 10^5
	Cubic feet	27.0
	Cubic inches	46,656
	Cubic meters	0.7646
	Cubic gallons	202.0
	Liters	764.6
	Pints (US liquid)	1,615.9
Gallons (Imperial)	Quarts (US liquid)	807.9
	Cubic inches	277.42
	Cubic feet	0.160544
	US gallons	1.20094
	US barrels	0.028594
	Liters	4.54596
	Cubic meters	0.004546
Gallons (US)	Cubic centimeters	3,785.0
	Cubic feet	0.1337
	Cubic inches	231.0
	Cubic meters	0.003785
	Cubic yards	0.004951
	Liters	3.785
	Pints	8.0
	Quarts	4.0
Gills	Liters	0.1183
	Pints (liquid)	0.25
Liters	Bushels (US dry)	0.02838
	Cubic centimeters	1,000.0
	Cubic feet	0.03531
	Cubic inches	61.02
	Cubic meters	0.001
	Cubic yards	0.001308
	Gallons (US liquid)	0.2642
	Pints (US liquid)	2.113
	Quarts (US liquid)	1.057

FORCE

To convert	To	Multiply by
Pounds per square inch	Kilograms per sq. m.	703.06687
	Inch of mercury	2.036009
	Feet of water	2.306009
	Atmospheres	.0680457
	Kilogram per sq. cm.	.07036
Kilograms per sq. m.	Pounds per sq. inch	.00142234
	Pounds per sq. foot	.2048169
	Inches of mercury	.0028959
	Feet of water	.003280833

WEIGHTS

To convert	To	Multiply by
Pounds (avoirdupois)	Grams	453.59
	Kilogram	.45359
	Ounces (avoirdupois)	16
	Ounces (troy)	14.5833
Pounds (avoirdupois)	Long tons	4.4643×10^{-4}
	Short tons	5×10^{-4}
Short tons	Kilograms	907.185
	Long tons	.892857
	Metric tons	.907185
	Pounds	2,000.00
Kilograms	Pounds	2.20462
	Short tons	0.0011023
	Metric tons	0.001
	Long tons	9.842×10^{-4}
Long tons	Kilogram	1,016.05
	Metric tons	1.01605
	Pounds	2,240
	Short tons	1.12
Metric tons	Kilogram	1,000
	Long tons	0.98421
	Pounds	2,204.6
	Short tons	1.10231

* U.S. Government Printing Office : 1985 -484-166/32824